UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

# FIELD METHODS FOR EVALUATING SOME FACTORS RELATING TO SOIL RECLAMATION AND RECOMMENDATIONS PERTAINING TO DRAINAGE

(For in-service use only)

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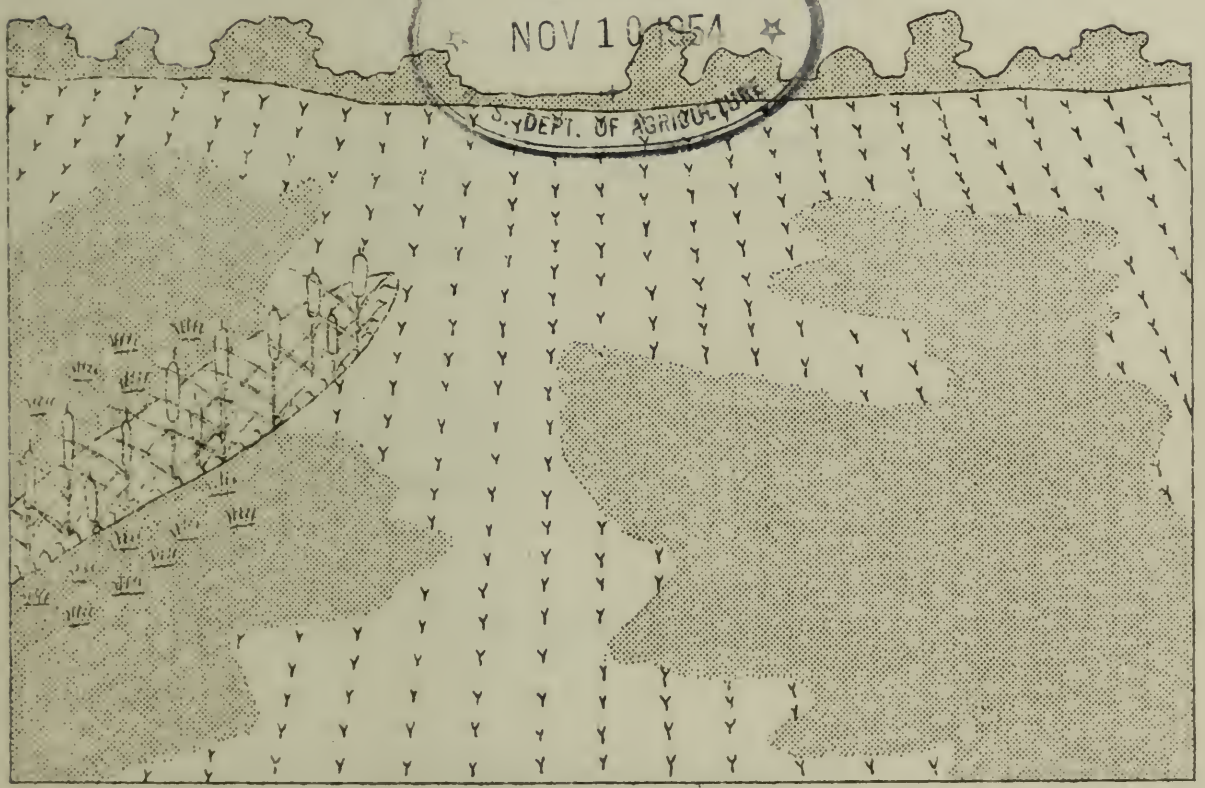

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# FIELD METHODS FOR DETERMINING SOIL RECLAMATION PROBLEMS AND RECOMMENDATIONS PERTAINING TO DRAINAGE



## ALKALINE SOILS

The solution of the soil problems inherent in the drainage of alkali soils are often as difficult and expensive as the drainage itself. Sodium saturated soils are frequently less useful after the drainage system is installed than they were before if proper soil amendments are not added prior to, or during the drainage process. Simple field tests can be made that will furnish a guide to the solution of the soil problem in reclamation.

The following field tests and interpretations are suggested as a guide for use in making recommendations or determining the extent of soil amendments necessary in a general drainage plan.

## LIME ($Ca\ CO_3$)

Objective:

To determine the presence and approximate amount of lime in the soil. This is a factor in the decision of whether to use gypsum or sulphur as a soil amendment. If the lime content of the soil is above one percent (by wt.) sulphur or sulphuric acid may be used, if it is cheaper or more practicable.

Method:

Effervescence with acid.
($Na_2\ CO_3$ will also effervesce)
($Mg\ CO_3$ will effervesce with hot acid)

Equipment needed:

Hydrochloric acid 10% solution (3 normal)

Procedure:

Hold sample of soil where close observation can be made and drop acid on it noting effervescence, if any.

Interpretation:

The soil may be termed none, slightly, moderately, or highly calcareous in accordance with the degree of effervescence obtained.

a. None - no visual reaction
b. Slightly - few bubbles and trace of reaction
c. Moderately - considerably bubbling, reaction not violent
d. Highly - boils up and reaction is violent

The approximate lime content corresponding to the above reactions are as follows:

Lime in Soil

| Degree of reaction | Lime in soil Percent | Lime/Acre Foot Tons |
|---|---|---|
| None | 0 to 1 | 0 to 170 |
| Slightly | 1 to 3 | 170 to 510 |
| Moderately | 3 to 8 | 510 to 1360 |
| Highly | 8 & above | 1360 & above |

## GYPSUM ($CaSO_4$) (7) 1/
(Available in the soil)

Objective:

To estimate the amount of gypsum in a given soil or water. The additional gypsum required to reclaim an alkali soil can be adjusted with respect to the gypsum inherently in the soil or water.

Method:

Precipitation with acetone

Equipment needed:

1. Glass funnel
2. Filter paper
3. Test tubes
4. Distilled water
5. Acetone

Procedure:

Place about two grams of soil in a test tube. Add approximately 5 cc of distilled water to each gram of soil and shake well. Allow soil water solution to stand for several minutes. Filter soil water solution to another test tube. Add an equal volume of acetone to the leachate and shake well. With a little experience, the approximate amount of gypsum present can be estimated from the appearance of the precipitate.

Groundwater, drainwater, irrigation water, artesian waters, etc., can be checked by placing about five cc of the water in a test tube and adding five or six drops of acetone.

e. Clear - Very little or no gypsum
f. Slightly milky - moderate gypsum
g. Visible precipitate settled to bottom - high gypsum

1/ Number in parenthesis refer to references.

## pH DETERMINATION [1] (2) (3)

Objective:

To determine the pH, which is a good indicator of alkali. (The degree of alkalinity is used in the recommendation on the quantity of gypsum or sulphur required to reclaim the soil).

On soils high in total soluble salt, the pH may not be a reliable indicator of alkalinity. However, after leaching the soil to eliminate buffer salts, the pH, or jump in pH, with dilution is a useful determination.

Method:

Determine with indicators

Equipment needed:

1. Spot plate
2. Color charts
3. Glass stirring rod (or tooth pick)
4. Distilled water
5. Indicator solutions 0.04% water solution
   a. pH 3.8 to 5.4 Bromcresol green
   b. pH 5.2 to 6.8 Bromcresol purple
   c. pH 6.0 to 7.6 Bromthymol blue
   d. pH 6.8 to 8.4 Phenol red
   e. pH 8.0 to 9.6 Thymol blue

Procedure:

Place about one-fifth (1/5) gram of soil in the spot plate. Add sufficient distilled water to the soil to nearly fill the spot. This gives about a one to five soil water solution. Stir the soil and water with the glass rod. Allow the soil water solution to settle for several minutes. This assures a more accurate pH reading and allows the water in the spot plate to clear up. Tip the spot plate and drain the free water into an adjacent hole in the spot plate. Add one or two drops of the indicator solution to the water in the spot plate. The pH is determined by comparison with the color chart. If the color of the water, after determination, is at either extreme range, the adjacent indicator solution should be used. The pH of water samples can be determined in the same manner.

[1] Field tests should be substantiated by ionic analysis as deemed necessary by the field technicians.

Interpretation: (Also see Table 5)

The soil may be termed acid or alkaline in the following categories:

h. pH 3.8 to 5.0 very acid
i. pH 5.0 to 6.0 moderately acid
j. pH 6.0 to 7.0 slightly acid
k. pH 7.0 to 8.5 slightly alkaline
l. pH 8.5 to 9.0 moderately alkaline
m. pH 9.0 + strongly alkaline

An estimate of the base exchange sodium saturation can be obtained by reading the pH directly on the soil with indicator solution only, and on a 1 to 5 dilution of soil to water. The following general criteria apply to soils having a pH above 7.5.

n. If the pH jumps 1.0 in the difference between a no dilution, and a 1 to 5 dilution, the base exchange is probably high in sodium.

   If a high total soluble salt accumulation is evident by a salt crust on the surface, free salt crystals in the soil, or is suspected from crop appearances by plant indicators, the soil sample should be leached with distilled water before making the pH change with dilution test. (A saline soil test should be made as well)

o. If the pH jumps from 8.6 with no dilution to 8.7 in the 1 to 5 dilution, it is an indication of low saturation of sodium in the base exchange.

# INTERPRETATIONS OF TESTS AND RECOMMENDATIONS FOR ALKALINE SOIL RECLAMATION PROBLEMS

| Item | | Results of test | Recommendations |
|---|---|---|---|
| | a. | None | Gypsum can be used for reclamation of alkaline soils, but sulphur or sulphuric acid cannot, unless applied with lime. |
| $CaCO_3$ | b. | Slightly | Gypsum or sulphur can be used for reclamation of alkaline soils. |
| | c. | Moderately | Gypsum or sulphur can be used for reclamation of alkaline soils. |
| | d. | Highly | Gypsum or sulphur can be used for reclamation of alkaline soils. |
| | e. | Slight | No gypsum available to aid in reclamation of alkaline soils. |
| $CaSO_4$ Gypsum | f. | Moderate | Some free gypsum available for reclamation of alkaline soils. |
| | g. | High | Considerable free gypsum available for reclamation of alkaline soils. |
| | 3.8 - 5.0 | h. Very acid | Gypsum or lime may be required for certain crops. |
| pH | 5.0 - 6.0 | i. Moderately acid | Gypsum or lime may be required. |
| | 6.0 - 7.0 | j. Slightly acid | No gypsum or sulphur required. |
| | 7.0 - 8.5 | k. Slightly alkaline | Soil should be tested for jump in pH with dilution. If the jump is 0.6 or more, the gypsum requirement test should be made. |
| | 8.5 - 9.0 | l. Moderately alkaline | The gypsum requirement test should be made. |
| | 9.0 + | m. Strongly alkaline | The gypsum requirement test should be made. |
| | 7.5 + | n. Jump of 1.0 or more with dilution | Generally indicates a high percentage saturation of sodium in the base exchange |
| | 8.6 | o. Jump of less than 0.6 with dilution | Generally indicates a low percentage saturation of sodium in the base exchange. |

## GYPSUM REQUIREMENT TEST 1/ (5) (6)
(Mc George and Breazeale test)

Objective:

To determine the approximate amount of gypsum required to reclaim an alkaline soil.

Method:

Gypsum adsorption

Equipment needed:

1. Test tubes
2. Gypsum solution saturated (0.25%)
   (Three grams plaster of Paris in one litre of water)
3. Acetone

Soil Sample:

The gypsum requirement test is calculated for 1/2 acre foot of soil. A representative six inch soil sample should be obtained, oven dried and thoroughly mixed. Additional six inch samples can be taken in the profile and the gypsum requirement figures added together to obtain total gypsum required for reclamation.

Procedure:

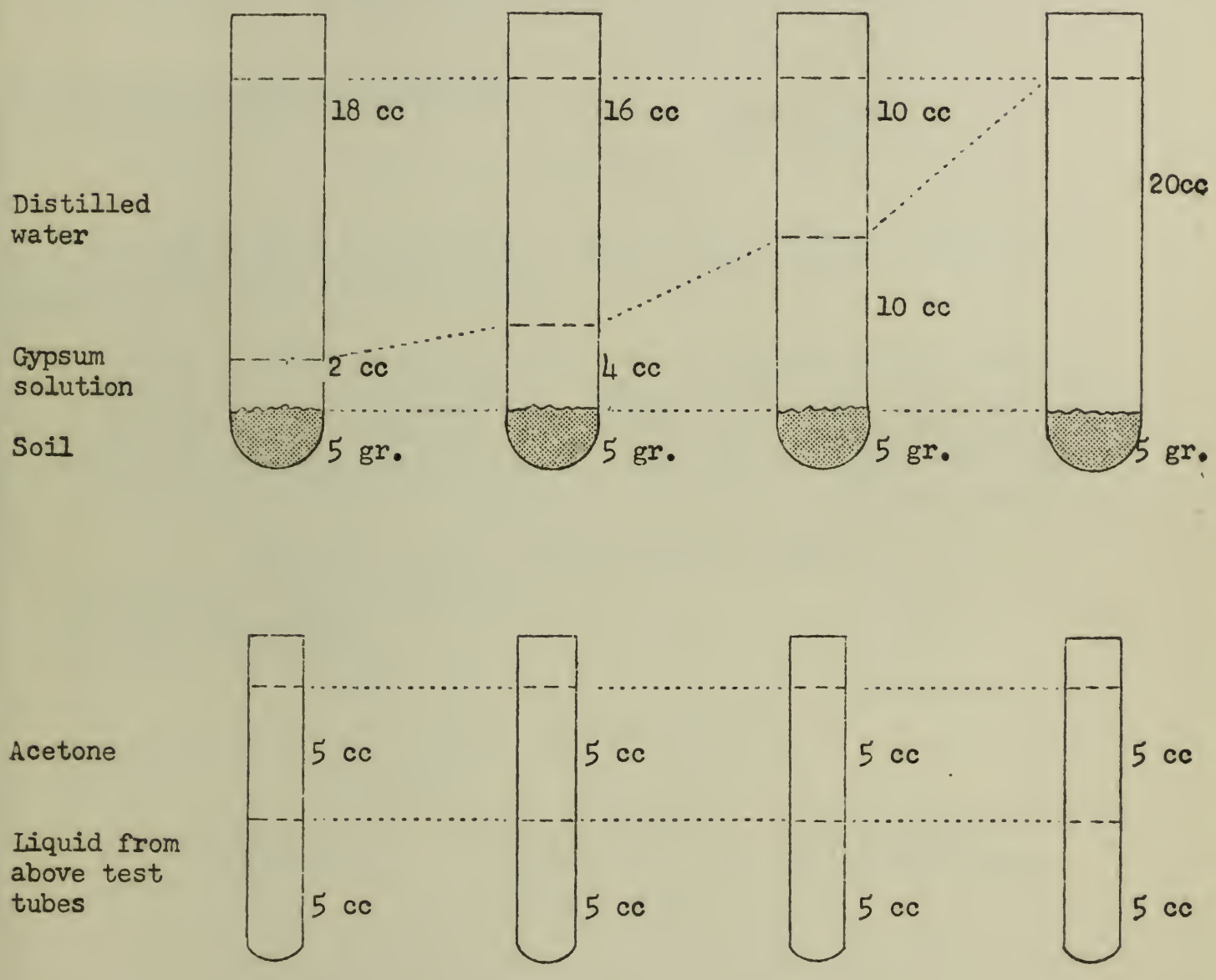
To five (5) gram samples of soil, add 2,4,10 and 20 cubic centimeters of gypsum solution. (This corresponds to an application of 1,2,5 and 10 tons of gypsum per acre.) Add water until the volume is about 25 cubic centimeters. Shake well and allow to settle for thirty (30) minutes. Decant supernatent liquid (about 5 cc) into test tubes and add an equal volume of acetone.

If free gypsum is present, a white precipitate will form. The amount of gypsum to be used corresponds to the amount added to the first sample to show free gypsum present in the supernatent liquid.

1/ Field tests should be substantiated by ionic analysis as deemed necessary by the field technician.

A sample of the soil with just water added should be tested, as many soils contain free gypsum.

Example



## CALCULATING THE GYPSUM REQUIRED (from chemical analysis) 1/ (7)

The following parts of a chemical analysis are necessary to compute the gypsum, sulphur or sulphuric acid required to reclaim a given soil.

1. Exchangeable sodium content in milliequivalents per 100 grams of soil.
2. Base exchange capacity of the soil in milliequivalents per 100 grams of soil.

The exchangeable sodium percentage is obtained by computing the percentage of the exchangeable sodium with respect to the base exchange.

$$\frac{\text{Exchangeable Sodium m.e./100 grams}}{\text{Total Base Exchange Capacity m.e./100 grams}} = \text{Exchangeable sodium percentage}$$

or

$$\frac{\text{Exchangeable Sodium m.e./100 grams}}{\text{Sum of all Cations}} = \text{Exchangeable sodium percentage}$$

Fifteen percent (15%) is generally excepted as the level of sodium percentage in the base exchange complex where harmful effects on the soil characteristics begin to be apparent.

To replace one milliequivalent of sodium per 100 grams of soil requires:

| Composite acre foot soil sample | Composite 1/2 acre foot soil sample |
|---|---|
| 1.75 tons of gypsum per acre | 0.88 tons of gypsum per acre |
| 0.33 tons of sulphur per acre | 0.16 tons of sulphur per acre |
| 1.0 tons of sulphuric acid per acre | 0.5 tons of sulphuric acid per acre |

(Required gypsum per acre foot of soil)

Exchangeable sodium percentage
Less 15% safe limit
Percent to be removed

Percent to be Removed $\times$ Base Exchange Capacity = Milliequivalent to be removed

Milliequivalent to be removed $\times$ 1.75 (Tons of gypsum required to remove 1 m.e.) = Tons of gypsum required per acre

1/ Memorandum by Wohletz, L. R., to California Soil Scientists, dated December 10, 1948. Subject, Soil Amendment Conversion Values.

## Sample Calculation

Silty clay soil (analysis of soil from 0 to 12 inches in depth)
Exchangeable Sodium - - - - - - - - - - - - - - - - - - - - 46.07 m.e./100 gm.
Base Exchange Capacity - - - - - - - - - - - - - - - - - - 55.3 m.e./100 gm.

Exchangeable sodium percentage = $\frac{46.07}{55.3}$ x 100 = 83.3%

| | |
|---|---|
| Exchange Sodium Percentage - - - - - - - - - | 83 |
| Less Safe Sodium Percentage - - - - - - - - | 15 |
| Percent to be removed - - - - - - - - - - | 68 |

m.e. to be removed = 0.68 x 55.3 = 37.6

Tons of gypsum required per acre = 37.6 x 1.75 = 65.8

66 Tons of gypsum required to reclaim the alkaline silty clay soil.

## SALINE SOILS (4) (7)

Objective:

To determine the total soluble salt content of the soil. The degree of salinity is used in recommending length of leaching periods on saline soils after an adequate drainage system has been installed and for land use planning.

Equipment needed:

1. Solu-bridge
2. Other standard equipment for making total soluble salt determinations.

Procedure:

Follow the standard methods for the equipment being used.

Interpretation:

The salinity of the soil is broken down into the following general categories: (7)

| | All crops thrive: little evidence of salt injury | Sensitive crops: do not thrive : tolerant crops may do well | Crop growth restricted yields usually poor | Only a few species survive |
|---|---|---|---|---|
| # 1 | 4 | 8 | 15 | |
| # 2 | 2500 | 5000 | 10,000 | |
| # 3 | 5 | 10 | 20 | |

# 1 Conductivity of the Saturation extract - millimhos/cm.

# 2 Parts per million of soluble salts (sample taken from first foot of soil)

# 3 Tons of salt per acre foot of soil (1st foot)

INTERPRETATIONS OF TESTS AND RECOMMENDATIONS FOR DURATION OF LEACHING ON SALINE SOILS (1)

| Permeability | | Duration of Leaching in days | | |
|---|---|---|---|---|
| 1 to 5 feet | 5 to 9 feet | 5 to 10* | 10-20* | 20 and over* |
| Rapid | Rapid | 0 | 0 | 0 |
| Moderate | Rapid | 0 | 20 | 30 |
| Rapid | Moderate | 20 | 40 | 60 |
| Slow | Rapid | 30 | 60 | 90 |
| Rapid | Slow | 40 | 80 | 120 |
| Moderate | Moderate | 50 | 100 | 150 |
| Slow | Moderate | 60 | 120 | 180 |
| Moderate | Slow | 70 | 140 | 210 |

* Tons per acre foot of soluble salts in the first foot of soil

| Rapid | Moderate | Slow |
|---|---|---|
| Coarse gravel | Sandy loam | Clay loam |
| Coarse sand and gravel | Loam | Silty clay loam |
| Sand | Silt Loam | Clay |
| Loamy fine sand | Clay loam | |
| Sandy loam | | |

(1) Bradshaw, G. B. and Donnan, W. W.
1952 Leaching Studies in connection with drainage of Saline Soils in the Imperial Valley, California

(2) Fireman, M., Mogen, C. A. and Baker, G. O.
1950 Characteristics of Saline and Alkaline Soils in the Emmett Valley Area, Idaho

(3) _____ and Wadleigh, C. H.
1951 A statistical study of the relation between pH and the Exchangeable - Sodium - Percentage of Western Soils

(4) Magistad, O. C. and Christiansen, J. E.
1944 Saline Soils - Their Nature and Management

(5) Mc George, W. T. and Breazeale, E. L.
1951 Absorption of gypsum by Semiarid Soils

(6) _____ and Breazeale, E. L.
1952 The Salinity Problem, Safford Experiment Farm, Field Experiments

(7) U. S. Regional Salinity Laboratory
1947 Diagnosis and Improvement of Saline and Alkali Soils

## REAGENTS AND EQUIPMENT FOR FIELD DRAINAGE INVESTIGATIONS

| Item | Some stores where obtainable | Approximate Cost |
|---|---|---|
| **pH Kit** | | |
| Spot Plates - No. 1 | Denver Fire & Clay | $ 1.58 |
| Color charts | Denver Fire & Clay | 0.60 each |
| Bromcresol green, 100 cc bottle pH 3.8 to 5.4 .04% water solution | Denver Fire & Clay | 1.50 each |
| Bromcresol purple, 100 cc bottle pH 5.2 to 6.8 .04% water solution | Denver fire & Clay | 1.20 each |
| Bromthymol blue, 100 cc bottle pH 6.0 to 7.6 .04% water solution | Denver Fire & Clay | 1.20 each |
| Phenol Red, 100 cc bottle pH 6.8 to 8.4 .02% water solution | Denver Fire & Clay | 1.20 each |
| Thymol blue, 100 cc bottle pH 8.0 to 9.6 .04% water solution | Denver Fire & Clay | 1.20 each |
| Oleo Red, 100 cc bottle pH 8.6 to 10.2 .04% water solution | Denver Fire & Clay | 1.20 each |
| Purple, 100 cc bottle pH 9.6 to 11.2 .04% water solution | Denver Fire & Clay | 1.20 each |
| Phenolphthalein 0.5% Solution in Ethyl Alcohol | Drugstore, local | 0.50 each |
| Field bottles | Drugstore, local | 0.15 each |
| Acetone | Drugstore, local | 0.50 each |
| Hydrochloric Acid Three normal solution | Drugstore, local | 0.50 each |
| **Permeability Equipment (1)** | | |
| Falling head permeameter | E. W. White | $ 40.00 |
| **Piezometric Equipment (2)** | | |
| ¼-inch black or galvanized pipe | Pipe Yard, local | 0.05-0.10ft. |
| Driving hammer | E. W. White | 15.00 each |
| Punch rods (removing rivet) 25 ft. | E. W. White | 6.00-25 ft. |
| Stirrup pump | Hardware store, local | 8.00 each |
| Seran tubing, ¼ x 031 (flushing piezometers) | Denver Fire & Clay | 0.20 ft. |
| Round head steel rivets, ¼" | Hardware Store | 0.20 lb. |
| A frame for removing piezometer 2 x 4 lumber, bolt, piece chain | Lumber yard, local | 4.00 |
| Piezometer pulling vice and jaws | E. W. White | 35.00 each |
| Caughing hoist | Hardware Store, local | 30.00 each |
| Electrical plumbing device | E. W. White | 60.00 each |
| Brass sounding bells | E. W. White | 3.50 each |
| Piezometer or well sounding plastic tubing | Denver Fire & Clay | 0.15 ft. |
| **Salinity Equipment** | | |
| Solu-bridge | Industrial Instruments, Inc. | $ 50.00 |

References

(1) A Falling Head Permeameter For Evaluating Permeability, by G. B. Bradshaw and W. W. Donnan, January 1950

(2) Methods of Determining Ground Water Levels and Movements, by W. W. Donnan and G. B. Bradshaw, January 1950

| Item | Some stores where obtainable | Approximate Cost |
|---|---|---|
| Drainage Soil Augers | Arts Machine Shop | |
| Five foot auger | | $ 12.50 each |
| Thirty foot auger | | 31.25 each |

Specifications for (Perrin Type) Drainage Augers

Augers:

Five foot auger

Auger: Soil, Orchard Type, light weight
Mercury cylinder sleeve, 6.25" long
3¼ diameter with detachable handle.

Thirty foot auger

Auger: Soil Orchard Type, lightweight
Mercury cylinder sleave, 6.25" long
3¼ diameter, with detachable handle
and five-five foot sections with threads and
unions for extension of 30 ft. over all length.

Addresses of equipment houses

Denver Fire and Clay, 413 South Eighth, Boise, Idaho

Industrial Instruments Inc., 17 Pollack Avenue, Jersey City 5, N. J.

E. W. White, Box 316, Imperial, California

Arts Machine Shop, American Falls, Idaho